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THE ROLE OF SLOW AND REAL TIME VIDEO MODELLING IN EXPERT AND  
NOVICE SOCCER PLAYERS

By

Brendan Teeling

A Thesis  
Submitted to the Faculty of Graduate Studies  
through the Department of Kinesiology  
in Partial Fulfillment of the Requirements for  
the Degree of Master of Human Kinetics at the  
University of Windsor

**Windsor, Ontario, Canada**

**2016**

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# The Role of Slow and Real Time Video Modelling in Expert and Novice Soccer Players

by

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September 12, 2016

### **Declaration of Originality**

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## **Abstract**

In order to learn a skill successfully, the interface between the coach and learner and particularly, the transmission of information from coach to learner is of critical importance. Observational learning is a method which can aid skill acquisition in sport. Observational learning is the ability to watch the behavior of others and to adapt that behavior as a result of this experience. This study examined differences between novices and experts' visual tracking behaviors while observing slow and real time video demonstration of a complex soccer skill. 32 female college aged participants were drawn as a convenience sample from the University of Windsor Lancer's soccer team ( $n = 16$ ) and students from the Department of Kinesiology ( $n = 16$ ), and were randomly assigned ( $n = 8$ ) to one of two video presentation conditions (slow motion vs real time video speed). Participants viewed an expert model performing a complex soccer skill. Gaze variability during viewing did not differ between groups. Novices and experts showed more attention initially, but decreased as a function of practice. Experts performed the complex soccer skill better than the novices, as one would expect. Interestingly, the real time experts performed better than the slow motion experts, suggesting that slow motion video speed hinders successful skill learning. Slow motion video observation on the contrary helped the novices learn the phases of the complex soccer skill. Moreover, research is needed to establish what experts focus their attention on while observing a skilled model. In turn, it is important to know whether or not observational learning tools such as slow motion or real time video speed can impact skill acquisition in soccer, as well as in a variety of other sports.

## **Acknowledgements**

This thesis would not have been possible without the help and support of many individuals. First and foremost, I would like to thank my advisors, Dr. Nancy McNevin and Dr. Michael Khan. I am extremely grateful to have had the opportunity to work with you both throughout my Master's program. Without your help, advice and valuable input; this would not have been possible. Without your incredible patience and timely wisdom and counsel, my thesis work would have been an impossible task.

I would like to express deepest gratitude to Dr. Kevin Milne for his full support, expert guidance and encouragement through my study and research. I also express my appreciation to Dr. Lori Buchanan for having served on my committee. A debt of gratitude is owed for sitting on my panel and taking the time to read my thesis. Your thoughtful questions and comments were valued greatly.

I would like to thank Coach Steve Hart for getting me over here to an extent on an athletic scholarship. My two years as a lancer athlete were extremely special and he has since helped me get my foot in the door for coaching.

Finally, I would like to thank my parents, brothers and sisters again for your unconditional love and support over the last two years. I would not have been able to complete this thesis without your continuous love and encouragement. Special mention must be made to Stefania who has been my rock over the past 9 months. Thank you for everything.

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# **Chapter 1**

## **Introduction**

Football (or soccer in North American) is known as the ‘world game’ due to its affordability, simple rules, and minimal equipment. The 2010 World Cup in South Africa was broadcast to 204 countries on 245 different television channels (FIFA, 2015). The ease through which sports are available to fans has subsequently led to increased viewer ratings in sports, even those with historically high viewership such as football, baseball, and basketball. The continued sponsorship and coverage of the Premier League (England), La Liga (Spain), MLS (USA), and the World Cup has led to more and more fans of ‘the beautiful game’. As an indicator of the popularity of football, approximately 715 million people across the globe watched the World Cup final in Germany in 2006 (FIFA, 2015). The FIFA World Cup Final in South Africa in 2010, featuring the Netherlands and Spain, reached a total audience of 909.6 million people, based on watching just one minute of coverage at home. This is an increase of 5 percent based on figures from the 2006 World Cup. The numbers for the FIFA World Cup Final in Brazil have yet to be consolidated but FIFA TV expects a bigger global audience than the World Cup in South Africa in 2010 (FIFA, 2015). Such is the increase in popularity of soccer in the USA as TV viewing figures for the FIFA World Cup in Brazil in the USA beat the TV viewing figures for both the 2014 NBA finals and the 2013 World Series (FIFA, 2015). Alongside viewer increases, participation rates have risen. According to FIFA’s most recent Big Count survey, over 265 million people play soccer around the world, with an added 5 million involved in refereeing accounting for approximately 4 percent of the world’s population (FIFA, 2015). Remarkably, the number of registered female players has

increased 54 percent (4.1 million) from the previous Big Count Survey in 2000 (FIFA, 2015). Given this high level of participation from grassroots to the international level, there is a need for a continued skill acquisition program to develop future stars Cristiano Ronaldo's and Lionel Messi's of the upcoming generations.

The 21st century has led to the development of modern marvels including very sophisticated smart phones, tablets, televisions, computers and software. Streaming services allow viewers to watch anything they can imagine in the palm of their hands, sometimes with a 360° view. With this influx in modern gadgetry and continued development of sophisticated applications for smartphones, tablets, etc., coaches, teachers and practitioners can utilize the concept of demonstrating and modeling through these media to enhance the learning of their students, athletes and patients. Lhuiset and Margnes (2015) found that a video demonstration led to better performance in the early acquisition of a complex judo movement than a live demonstration. Furthermore, observational learning can maximize the early acquisition of skill learning in sport, particularly with the use of modern technologies. These tools would be particularly useful for volunteer coaches at the grassroots level. Perception is vital to imitation, modelling and observational learning. There is an extensive selection of inter-related expressions within the published work, most notably, 'mimicry', 'vicarious learning', 'social facilitation', 'copying', 'ideo-motor action', 'emulation', 'allelomimesis', 'echokinesis' and 'match-dependent behavior'. These terms are found throughout the observational learning literature (see Sluckin 1970., for an in depth analysis of observational learning and modelling taxonomy). However, there are few studies that examine slow motion or real time video modelling for learning novel complex techniques (Scully & Carnegie, 1998; Al

Abood, Davids, Bennett, Ashford, & Marin , 2001; and Fagundes, Chen & Laguna, 2013) and even fewer reflect which type of video playback is more beneficial for the learning of a complex skill in novice and elite athletes. Furthermore, the visual search strategies of experts could influence the type of feedback or direction coaches, teachers and practitioners could use to influence learning of their players, students or patients. Consequently, this study was designed to investigate and compare the utilization of visual search strategies between experts and novices in the observational learning of a complex soccer skill while viewing slow motion and real time video models.

## **Chapter 2**

### **Literature Review**

#### **Observational Learning**

In order to learn a skill successfully, the interface between the coach and learner, and particularly, the transmission of information from coach to learner is of critical importance. Coaches can convey information via verbal, written, visual instruction (diagrams, tactics boards, white boards). Demonstrating is one of the more commonly used modes of information transfer. Demonstration is typically most important during the initial stage of the skill acquisition process (Graham, Holt-Hale and Parker, 2001; Rink, 1998). Observational learning occurs when one watches the behavior of others and adapts behavior as a result of this experience. Action observation is the ability to observe oneself or a model, either video or live, performing the desired action successfully (Neuman and Gray, 2013). As part of the observational learning, imitation is the core process through which this emulation occurs. At the most basic level, during imitation, the observer adopts the behavior of the model that they would not have if the model was not presented. (Sluckin, 1970). Using observational learning, a learner can watch the behavior of another and adapt his or her own behavior to duplicate more closely the outcome or process of the event (Williams, Davids and Williams, 1999).

Miller and Dollard (1941) categorized imitation as being either a match dependent behavior or copying behavior. Match dependent behavior refers to situations where the “imitator” is dependent on the leader for action. The leader’s cue in this situation is the environment whereas the imitator’s cue is the response of the leader. Copying is the process whereby the observer adapts his/her response to be more like the model. Copying is more critical and deliberate than matched-dependent

behavior. In the motor skill acquisition domain, copying is the more appropriate behavior. This is because the athlete/player who ‘copies’ the model is not necessarily dependent upon the model to perform the skill, but uses the information gained from the observation of the model to replicate the skill being performed. Imitation has also been defined as the copying of a component feature of the body movements of a model (Heyes, 2001). During imitation the learner preserves the relative timing of the action whereas, copying allows the learner to inject their own individual differences into the action.. Copying in this context implies a causal relationship between the observation of a feature of a model’s body movement and the execution of a body movement with the same feature by the observer.

In their classic Bobo doll study, Bandura, Ross and Ross (1961) demonstrated that children exposed to live aggressive adult models replicated aggressive behavior in a new situation in the absence of the model. This is one of the earliest studies that accentuates the strength of visual models on subsequent imitation learning. As a consequence of this study, Bandura, Ross and Ross (1963), conducted a subsequent Bobo doll study that looked at the extent to which aggressive models that were viewed by children on a television screen led to imitative behavior in that domain in a subsequent scenario in the absence of the model. Bandura et al. (1963) found that children who viewed aggressive models on a television screen reproduced aggressive behaviors. In fact, subjects who viewed aggressive human and cartoon models on a television screen displayed twice as much aggression than the subjects in the control group who were not exposed to the aggressive content. Both of these studies highlighted the importance of modeling behavior on children’s subsequent imitative behavior in everyday life.

The concept of observational learning stems as far back as Bandura's observational learning theory (1961). While this focus was more in the area of social psychology, observational learning theory has wider implications to how one learns from watching demonstrations (McMorris, 2004). This concept has been adapted to the motor learning domain. As stated by Bandura, we learn by observing the behavior of others and the consequences of that behavior, in either a deliberate or incidental manner (McMorris, 2004, Bandura, 1977). Sheffield's (1961) systematic representational theory was developed to assess the effectiveness of filmed demonstrations in the learning of mechanical assembly tasks. This shift from traditional stimulus response reinforcement proved a major step toward developing a testable theory of learning in complex human motor skills. This theory postulates that when one observes a skill, the observer internally represents a cognitive representation of the action through methods of contiguity and association. This furthermore acts as a blueprint to guide matched skilled behavior.

Bandura (1986a, b) developed his social cognitive theory based on Sheffield's systematic representation theory, which had been the foundation of the bulk of research in observational learning. He extended Sheffield's systematic representation to include the acquisition and modification of behavior and social skills (Williams et al. 2009). The sub processes of attention, retention, production and motivation are the outstanding processes through which a learner can cognitively represent a modeled behavior (Bandura, 1977). In other words, behaviors and skills are learned through observation, imitation and reward or punishment (Bandura, 1969, 1977, 1986, 1997). The above processes include two distinct phases; the response acquisition phase and the performance reproduction phase. During the response acquisition phase, the observer encodes and rehearses a skill in one's mind. During the performance

reproduction phase the observer successfully performs the coded behavior. The sub-processes of attention and retention are inextricably linked in that the cues, which are attended to during a demonstration, are subsequently coded for later reproduction and are essentially retained through visual or verbal representations. It is important to note that according to Bandura (1997) the entire demonstration is not coded, but a component of the movement is retained for later reproduction.

### **Stages of learning**

Traditional theories of motor control and learning, epitomized by Schema Theory, the specificity of learning hypothesis, or the theory of deliberate practice (Proteau, Marteniuk and Lévesque, 1992; Schmidt 1982, 1988; Ericsson, Krampe and Tesch-Römer, 1993), reveal very little about the emergence of coordination.

Traditional approaches to early learning concentrate on verbalization, active cognition and dependent feedback from independent agents such as a coach or teacher. These cognitive approaches to skill acquisition have tended to focus on the outcome of the learning process rather than the learning process itself. The theoretical basis of the ecological approach (i.e. dynamic systems theory) affords a reassessment of the learning process and unveils a very different outlook on the learning process. A three stage model of skill acquisition (coordination, control and skill) was proposed by Newell (1985). To ecological theorists these processes of coordination, control and skill reflect the phases in movement organization over the course of skill learning as one moves from a state of competition between the demands of the task and the existing dynamics towards a state of cooperation. (Hanford, Davids, Bennett and Button, 1997; Newell, 1985).

Coordination is the first stage of this three stage model. Within this stage the learner must discover the relationship between the task demands and their intrinsic



dynamics (the existing capabilities the learner brings to the task). One characteristic of coordination is the relative timing of component actions. During early stages of learning, the athlete's first goal is to identify and improve their relative timing of the actions underlying the motor task through discovery or trial and error. This requires the athlete to simplify the control problem by keeping the body rigid by constraining some of the degrees of freedom as they try soft assemblies of the skill. As a consequence of these constraints on the degrees of freedom, novice performance is inflexible and inefficient. With more practice, the learner identifies and more easily reproduces a coordinative structure (i.e. the assemblage of muscle synergies) specific to the task demands, and is able to free the degrees of freedom in order to identify more efficient ways of performing the skill. This step in the learning process allows the learner to learn by "self discovery". What does this mean for the coach/teacher? In this stage the coach or teacher should help the learner 'discover' the relevant task and coordination dynamics by constraining the learning situation to assist the optimal discovery environment (Handford et al., 1997).

The second phase is termed the control phase. This phase involves the discovery of the appropriate control parameters that drive the system through its stable states and developing movement patterns (Newell, 1996). Moreover, this phase involves the parameterizing of the skill. The athlete assigns different values to the underlying motor coordination to try and maximize the best way to perform the skill and subsequently improve the absolute timing of the task. As the learner's skill increases a number of degrees of freedom become unfrozen and subsequently integrated into larger functional units of coordinative structures. Handford and colleagues, (1997) propose that the coordinative structure becomes task specific

during this phase. The coordinative structure becomes directly related to perceptual information, ultimately organizing the required perception-action coupling.

Skill is the final stage in which the learner has transitioned from a novice to an expert. The expert has acquired the optimal control parameters in performing the desired skill. The skilled learner exploits non-muscular forces rather than trying to minimize or compensate for them. The movements of highly skilled performers are both energy efficient and appear effortless. There is less variability or a greater consistency in performing the action under pressure. The skilled performer also displays flexibility in changing the movement coordination and control solution to adapt to changes in the performer-environment interaction and task goals.

### **Visual Search Strategy**

Performers have to make quick decisions in a complex and ever changing environment in a variety of sports. For example, football, hockey and soccer players must decide on an appropriate action based upon information from the ball, team-mates and opponents (Williams et al., 1999). Decision making in these sports must be made under pressure with opponents restricting both the time and space available to perform. Players must focus their attention on the most crucial and relevant sources of information in order to maximize successful performance in such contexts. Important aspects of skilled performance are knowing ‘where’ and ‘when’ to look. In recent years, performers’ eye movement and focus on selected areas of a display have received a significant amount of interest (Gegenfurtner, Lehtinen & Saljo, 2011; Jarodzka, Scheiter, Gerjets and Van Gog, 2010; Balslev, Jarodzka, Holmqvist, De Grave, Muijtens, Eika Merrienboer & Scherpbier, 2012; Williams & Davids, 1998; Mann, Williams, Ward & Janelle, 2007; D’Innocenzo, Gonzalez, Williams & Bishop, 2016). The visual search patterns portrayed by experts are based on deliberate

perceptual strategies, whereby eye movements are controlled to make more efficient use of the time available for analysis of the display (Bard & Fleury, 1981). Abernathy (1985) extended this concept by stating that both the fixation location and duration of visual search strategies are indicators of the perceptual strategy used by the athlete to extract meaningful information from a demonstration or other display.

Researchers have shown that elite athletes tend to display more efficient gaze patterns than their novice counterparts (Gegenfurtner, Lehtinen & Saljo, 2011). Skilled athletes generally require fewer fixations of longer duration to extract task relevant cues, which portrays an exceptional efficiency of their gaze behavior (Williams & Davids, 1998; and Mann, Williams, Ward & Janelle, 2007). Furthermore, experts are considerably better at ignoring task irrelevant stimuli compared to novices (Jarodzka, Scheiter, Gerjets & Van Gog, 2010; Balslev, Jarodzka, Holmqvist, De Grave, Muijtens, Eika Merrienboer & Scherpbier, 2012). Gegenfurtner et al., (2011) and Peterson and Eckstein (2014) suggest that this skilled gaze behavior is borne out of substantial practice.

Performers in all fields who are confronted with the difficult task of identifying and processing relevant information in sport engage in the process of visual search. For example, consider arguably the best soccer player in the world, Cristiano Ronaldo. While dribbling on the field, Ronaldo will be required to identify information from the ball, the position of the goal and the position of his teammates and opponents, and use this information quickly in deciding to pass or shoot the ball; a skill many athletes practice for years to develop. Visual search behavior is generally investigated using an eye movement registration technique. Much of the literature conducted on visual search has examined the links between visual search and anticipation (Savelsbergh, Van der Kamp, William & Ward, 2005; Singer, Cauraugh,

Chen, Steinber & Frehlich, 1996; North, Williams, Hodges, Ward & Ericsson, 2009), expertise (Abernathy & Russell, 1987; Vickers 1988), verbal instruction and image size (Al-Abood, Bennett, Hernandez, Ashford & Davids, 2002), talent identification (Williams, 2000) and the visual behavior of coaches in identifying a performance error (Romero, Del Campo, Vaillio & Hernández, 2006). In soccer, researchers have investigated the role of visual search in improving the accuracy of a soccer penalty kick (Wood & Wilson, 2012); the role of anxiety in taking an important penalty kick (Wilson & Wood, 2009); the role of visual search executing a power vs placement penalty kick (Timmis, Turner & Paridon, 2014); and the anticipation and decision making of soccer players in a realistic video display (Roca, Ford, McRobert & Williams, 2011). However, there is a noticeable gap in the domain of visual search during observational learning and skill acquisition.

D’Innocenzo, Gonzalez, Williams and Bishop (2016) investigated the effects of visual guidance on the observational learning of a golf swing. D’Innocenzo et al. (2016) were particularly interested in knowing if highlighting relevant cues of a golf swing promoted improved learning. By using translucent color patches superimposed over important regions of a model golfer’s body and apparatus (ball and club) to draw attention to those relevant cues, the researchers found that novices’ accelerated their observational learning of a golf swing.

Horn, Williams and Scott (2002) investigated visual search behaviors during the observation of a soccer chip (lofted soccer pass). In response to video models, point light models and the absence of a model, the participants visual search behaviors were compared to determine the effectiveness of the type of demonstration (video or point light) in facilitating correct movement form and task outcome. All three groups developed greater accuracy on the task alongside a decrease in outcome

variability. Participants who observed the video and point light display models increased their step patterns to match those of the models. In other words, the observation of a model facilitated the acquisition of models, global pattern of coordination. The visual search analysis revealed subtle differences between the point light display and video groups. The data was consistent in that those who observed a point light display showed more refined visual search patterns than those observing a video model.

In a follow up study, with the absence of intrinsic visual Knowledge of Results, video and point-light demonstrations improved the learning of the soccer chip (a short elevated pass) and, in particular, conveyed the rapid adoption of an intralimb relative motion (Horn, Scott, Williams and Hodges, 2005). Knowledge of results is defined as extrinsic or augmented information provided to a learner after a response, indicating the success of their actions with regard to an environmental goal (Salmoni, Schmidt, and Walter, 1984). Visual intrinsic Knowledge of Results was removed because Horn et al., (2002) proposed that Knowledge of Results diminishes the model's influence and constrains the movement choices available to the observer. Intrinsic Knowledge of Results is a method through which the learner can detect error and correct movement form to help successfully perform the task outcome from oneself. Without intrinsic Knowledge of Results, participants learned to generalize the models relative motion pattern but did not learn how to reduce error (Horn et al., 2002). Furthermore, the presence of Knowledge of Results seems to advocate the parameterization of the movement pattern. The absence of intrinsic visual Knowledge of Results results in immediate refinement of the movement pattern, evidenced by rapid changes in relative motion, followed by stable movement patterns.

Afonso, Garganta, McRobert, Williams and Mesquita (2014) examined eye movement recordings and verbal reports of thinking when exploring the processes involved in a representative volleyball task involving both film-based and in-situ data collection. This study investigated the mechanisms underpinning a complex, representative volleyball task. Film-based and in situ live-action conditions demonstrate that skilled decision making differed based upon both of these types of media. In this study, participants in the in situ condition exhibited longer fixation locations and percentage viewing time in terms of looking at the attacker compared to the video looking at a potential attacker. The in situ group relied more upon a potential anticipatory cue.

A study conducted by Ariel and Castel (2014), which sought to confirm whether more attention was devoted to high value visual items (i.e., the resource allocation hypothesis) examined how learners selectively encode information using eye tracking methodology. Attention was assessed by examining pupil dilation in participants who were studying high-valued words compared to low-valued words. The words were concrete monosyllable nouns containing 5 letters (e.g., truck) and were similar in frequency. Findings indicated that participants' pupils dilated more when studying high valued words, which was also associated with improved memory for those words relative to low valued words. In a similar vein, evidence has shown that increases in the size of the pupil of the eye have been found to coincide with the viewing of interesting visual stimuli (Hess and Polt, 1960). This is one of the first studies that showed how pupillary changes mediated by the sympathetic nervous system could be a measure of greater or less interest and pleasure value of visual stimuli while viewing visual material of different kinds. One of the main findings of this study was that pupil dilation was greater for men when viewing a partially nude

woman, while greater pupil dilation was seen for women viewing partially nude men. Taken together, these results suggest that pupil dilation can be used to assess greater interest or attention to visual cues, and as such, might provide a medium for assessing the attentional demands associated with viewing a model performing a novel task.

Monitoring the gaze behavior of novice/expert participants' learning a complex skill could potentially identify the perceptual-motor relationship of novice/expert learners. Pupil diameter has been shown to increase when viewing interesting or emotional visual stimuli (Hess Polt, 1960). Identification of "what" experts view while observing a skilled model could help coaches, teachers and practitioners to develop a guide to complex skill learning and provide feedback on where and what are the key areas to focus on during the observation of a complex skill.

### **Motor skill acquisition and video demonstration**

The studies examining the influence of video speed on observational effects have focused on the characteristics of the movements. Scully and Carnegie (1998) compared the effects of slow motion speed, real time speed and picture modeling on the performance of a complex ballet jumping skill for beginner ballet dancers. Those participants in the slow motion video group performed significantly better than the other two groups (regular time video and point light modeling) in terms of movement time, foot placement upon landing and relative timing. However, slow motion impaired the acquisition and replication of the control parameters (i.e., absolute timing/speed of movement and force production). The authors found that slow motion video rapidly improved participants relative timing of the task. This supports the results of Williams (1989) who showed that slow motion modeling assisted the acquisition of the correct relative timing of an over hand throwing motion. Williams

(1989) investigated whether videotaped demonstrations which only displayed the motion pattern of a model's limb during an action compared with one which showed both the form and motion provided enough information for modelling a given movement pattern. Analysis showed that after four trials under all conditions, the correct order of preparatory action was produced. Therefore, the results in these studies indicate that slow motion enhances the pick-up of kinematic information by emphasizing the relative motion pattern. However, slow motion tends to distort kinetic information pick-up by exaggerating the absolute timing components of a visual display.

The effectiveness of observational learning is showcased in a study by Sakadjian, Panchuk and Pearce (2014). This study investigated how Australian footballers used action observation in the development of a complex powerlifting technique, the power clean. Action observation through an expert model demonstrating the power clean on a video showed faster and better learning of the power clean technique (Sakadjian et al., 2014). It also improved performance when combining action observation with conventional techniques compared to learning the same technique without action observation (Sakadjian et al., 2014). Another study by Scully and Carnegie (1999) showed that slow motion demonstrations improved movement time and relative timing of a complex skill and were consistent with the findings of Cutting and Proffitt (1982) who found that real time demonstrations of actions establishes accurate perceptions of a coordinate frame of reference unique to each activity. These studies emphasized the importance that both technology and observational learning have on skill acquisition for athletes. Several studies demonstrate the efficacy of slow motion video modeling on early stages of skill acquisition, however, benefits are not always found (as described below).



Al Abood, Davids, Bennett, Ashford and Marin (2001) compared slow motion and regular time video in a novel modified under arm dart throwing task. This study suggested that slow motion demonstration was actually detrimental to spatial and temporal relative motion and performance. Participants who observed slow motion demonstrations were incapable of perceiving intact relative motion information, which subsequently resulted in a less accurate estimation of the relative motion patterns of the model. Further, Al Abood et al (2001) supported the work of Barclay, Cutting and Kozlowski (1978) who reported inferior recognition of actions (identifying sex of walkers) after observing slow-motion displays. El Abood et al. (2001) propose that slow motion demonstrations may be useful towards the latter stages of learning to direct the learners' attention to a particular detail of performance, specifically, for tasks with multiple sub-components and varying temporal parameters. In other words, slow motion video may be useful when the task becomes more complex. The findings of this study further suggest that the impact of visual demonstration speed on perceiving and performing a task is a function of the novelty or familiarity of the relative motion of underlying the task.

Studies examining the role of slow motion video modeling or demonstrations have resulted in conflicting results. These differences have been attributed to the type of task being learned (complex vs. simple) (Scully and Carnegie, 1999; Cutting and Proffitt, 1982), the stage of learning the actor is in (Al Abood et al., 2001), and a learner's familiarity with the relative timing of the task (Al Abood et al., 2001). As such, it may be useful to identify the effect of slow motion video demonstration on the acquisition of a novel complex motor task during early (novice) and later (expert) stages of learning to assess when it can most effectively be used. Perhaps slow motion video demonstrations would be useful at the beginning of skill learning or in the latter

stages of skill learning to fine-tune a complex task.

### **The Present Study**

As a result of this gap in the literature in the larger domain of observational learning and visual search methods during motor skill acquisition, there is a need to identify differences between novices and expert visual tracking behaviors while observing slow and real time model demonstration. The aims of this study were to identify performance differences between experts and novices as a function of slow motion and real time video presentation of model and to identify visual search strategy differences between experts and novices viewing a model at slow motion and real time video speed.

Ultimately, there is a need to determine whether any differences/similarities can be used to develop a useful training medium. A complex skill will be defined here as a movement that cannot be mastered in one session by a novice and has multiple degrees of freedom (Wulf and Shea, 2002). A novice soccer player will be defined as somebody who has not played organized soccer for more than one year.

To address the research questions for this study, experts and novices were randomly assigned and exposed to either a slow motion or real time video model's demonstration of a complex soccer skill that may be used in a game type situation. To identify differences in visual scanning behavior as a function of model presentation speed, gaze variability and pupil diameter were monitored during observation trials.

### **Hypothesis 1: Visual search data**

It was hypothesized that slow motion novices would show less variable gaze patterns compared to real time novices, suggesting greater attunement to the relative

motion (foot movements) of the body while watching an expert perform a complex soccer skill.

It was also hypothesized that slow motion novices would have higher arousal levels (dilated pupils) than real time novices (suggesting increased attention). Finally, it was hypothesized that experts regardless of presentation speed would show less variable gaze patterns than novices and lower arousal levels compared to novices.

### **Hypothesis 2: Skill acquisition**

It was hypothesized that the slow motion video speed groups across skill level would lead to faster improvements in the relative timing characteristics of the soccer skill (i.e., coordination). Further, that Real time would improve overall absolute timing of the task (i.e., control). Finally, it was hypothesized that experts should show faster acquisition of each phase of the skill, and greater target accuracy than the novices.

## **Chapter 3**

### **Methods**

#### **Participants**

Thirty-two female college aged participants were drawn as a convenience sample from the University of Windsor Lancer's soccer team ( $n = 16$ ) and students from the Department of Kinesiology ( $n = 16$ ), and designated as either expert or novice based on their level of playing experience. The sample was further broken down by randomly assigning 8 experts and 8 novices to one of two video presentation conditions (slow motion vs real time video speed) in a 2 (expertise: expert vs. novice) X 2 (video: slow vs. real time) design. Novice players were defined as having played less than one season of organized soccer at recreational level. Expert soccer players had to have played organized soccer for a minimum of 10 years (Gladwell, 2008). All participants had normal to corrected-to-normal vision, were right foot dominant and all completed and signed an approved informed consent to participate agreement and consent for videotaping agreement.

#### **Soccer Skill Movement Task**

The task entailed performing a roll over which combined a step over sequence followed by striking a soccer ball accurately with proper form (with the inside of the right foot) towards the target (see Figure 1, Photo 7). A size-five Adidas Tango, 32 panel soccer ball was used for this task. The ball was placed on a 10 x 10cm "X" on the back right hand corner of an artificial turf, which identified the starting position for the soccer ball for each trial. The artificial turf (3.048 x 2.44 m) area served as the total maneuvering area for the participants to perform the complex soccer task before striking the ball at the stationary target. The stationary target, a 10.5 cm x 15cm high traffic cone, was positioned directly in the center of the artificial turf and located 2.3

m away from the X mark located on the turf. The target dimensions represented the approximate size of a human foot; the intended target in an applied context. The complex skill was broken down into 3 Phases (Figure 1) during analysis due to the complexity of the skill and to allow analysis of separate components of the skill across practice trials. Phase 1 consisted of the roll over the soccer ball with the participants' right foot (Figure 1). Phase 2 consisted of the stop with the left foot and step over with the right foot (Figure 1). Phase 3 consisted of the passing technique (right foot pass) (Figure 1).

## **Materials**

A Go-Pro 3+ video camera (San Mateo, CA, USA) was used to videotape the expert model performing the complex skill. The model portrayed in Figure 1 is the primary investigator and had given consent to use the pictures. A Dynex 40 inch LCD (1080p) TV monitor (South Richfield, MN, USA) was used to deliver the video modeling treatments. The iMovie application on the MacBook air (Apple Inc., San Cupertino, CA, USA) was used to slow down the video model of the complex soccer skill to 50% of the video recording's regular speed. The Go-Pro 3+ was also used to videotape the participants' attempts at executing the complex soccer task. The Go Pro App (San Mateo, CA, USA) was used to analyze the movement patterns of each participants across each trial.

## **Video Model**

The participants were presented with the videotaped demonstration of the complex soccer skill being performed by a highly skilled, female model, who was a member of the University of Windsor's soccer team. Because of the complexity of the soccer skill, a skilled model was used. In order to protect her identity her face was

blurred using video editing technology. The video was created to isolate one correct execution of the task and looped to provide participants 8 identical observations of the skill. The video speed manipulation consisted of the same 8 trials presented at 60 frames per second for a trial duration of 54 seconds for the Slow motion video, or 27 seconds for real time trial duration. Selection criteria emphasized a clean, smooth roll over plus a step over followed by a clean strike of the ball with the inside of the models right foot which hit the target cone. The skill was videotaped in the frontal plane, using a Go-Pro 3+ video camera. This allowed the model's movement dynamics to be viewed.

### **Instrumentation**

An eye movement registration system (4000, SU; Applied Science Laboratories [ASL], Waltham, MA) was used to record visual search data. This apparatus measures eye line of gaze patterns using head mounted optics. The ASL works by gathering three pieces of information: 1). displacement between the left pupil and corneal reflex (i.e. the reflection of the light source from the surface of the cornea, 2). the relative position of the eye in the head, and 3). the orientation of the head in space.

### **Procedures**

Evaluation was conducted individually in the motor control lab at the University of Windsor. All participants followed the same experimental procedures but differed with respect to whether they observed normal videotaped demonstrations or slow motion videotaped demonstrations.

Eye movement data was recorded while the participants observed the demonstrations of the complex skill in either slow motion or real time video. Before

the collection of eye movement data, the procedures of the study were explained and the ASL system was fitted to the participant's head and calibrated. The ASL system is renowned for being robust and not requiring frequent recalibration (Williams et al., 1999).

Following calibration of the eye-tracking system, the complex skill was presented on the TV monitor in either slow motion or real time video speed to the particular groups. The participants wore the eye tracking system head mount for the duration of the first block and last block while observing the skilled model on the TV. The entire experimental session delivery took no more than twenty minutes to complete per participant.

Before performing the complex skill, all participants were exposed to 8 repetitions of the skilled model performing the skill (action observation), which was the same number of repetitions subjects were required to physically perform in a row before watching the video again. This was repeated for 6 blocks adding up to 48 trials in total. These videos were pre-recorded videos of the skilled model performing the complex skill followed by hitting the target. Before observing the model, all participants were informed that their task was to use the video demonstration to assist them in performing the soccer skill to the best of their ability, with the goal of enhancing performance of the skill and to improve their shooting/passing scores. None of the participants were instructed to focus on any particular part of the model's actions so that their natural gaze behaviour could be monitored.



**Figure 1.** The complex soccer skill as demonstrated by primary investigator (female soccer player used in study): Phase 1 (photo 1-4): The roll over with the right foot; Phase 2 (photo 4-7): The step over movement (right foot steps over soccer ball while left foot simultaneously touches the ball back in the direction it first came in); and Phase 3 (Photo 7-9): Passing technique (inside of right foot)

## Data Processing and Dependent Variables

### Visual Search Data.

Two dependent variables were used to analyze the visual search strategies: (1) pupil size (level of arousal), and (2) Gaze variability.

The ASL Eye-Trac 6 Eye Movement Recorder System was calibrated using a simple nine-point reference grid that over-lapped the area on the monitor depicting the expert model video demonstration. Calibration was performed for each of the participant prior to observation trials, and required participants to fixate on each of the



nine calibration points as instructed by the experimenter. This ensured that the fixation point corresponded precisely to the participants' point of gaze on the video screen. Data was sampled from the pupil and corneal reflection. The separation between the pupil centre and the corneal reflection centre is the raw data measured by the eye tracker. The relationship between the raw values obtained and the eye line of gaze differed for each participant and for different scene camera positions and optical units. The main aim of the eye calibration was to provide information that allowed the eye tracker data processor to account for individual differences within subjects. The sampling frequency was 120 Hz.

#### **Gaze Variability.**

For each data point, the absolute distance of point of gaze from the centre of the display was calculated. Within-trial standard deviations of these absolute distances was then calculated and used as a measure of variability in visual gaze patterns. Raw data was exported to Microsoft Excel and both the means and standard deviation scores were calculated. Lower values indicated a higher number of fixations (or static viewing) on specific model actions.

#### **Pupil Dilation/Level of Arousal.**

Mean scores for each block were calculated based on pupil diameter for each trial. Larger pupil diameters meant higher levels of arousal, suggesting greater attention to demonstrated actions of the model, while smaller pupil diameter meant lower levels of arousal/attention. Raw data was exported to Microsoft Excel and mean scores were calculated by the primary investigator.

## **Soccer Skill Movement Task**

### **Target Scores.**

Target scores were calculated as follows: the participant was awarded a score of 1 for striking the central target and a score of 0 if they failed to hit the central target. For each participant, scores were summed across each block and a mean score was calculated in Excel. Because the resulting data yielded a bimodal distribution of scores, parametric analysis could not be performed due to violations to assumptions. As such, descriptive statistics (means and standard deviations) were calculated separately for each condition which allowed comparison of success and failure of the skill across blocks of practice.

### **Success Rate of Complex Soccer Skill.**

The second measure involved rating form in the complex soccer footwork task. The skill was broken down into three continuous phases:

1. Phase one consisted of the roll over the soccer ball with the participants' right foot;
2. Phase two consisted of the stop with the left foot and step over with the right foot;
3. Phase three consisted of the participants passing technique.

Participants received a performance score on their movement form on each of the aforementioned phases. The primary investigator subjectively evaluated success and failure of each phase by determining whether the appropriate action was performed. Participants were awarded a score of 0 if a particular phase was performed inaccurately or a score of 1 if the particular phase was performed accurately (used correct part of foot, kept ball close to body, struck the ball with the correct part of

foot, and so forth). For each participant, scores were summed across each block and a mean score was calculated in Excel. Again, because the resulting data yielded a bimodal distribution, which violated assumptions of performing a parametric test, descriptive statistics were calculated separately for each condition which allowed comparison of skill level across blocks.

### **Timing of Phases.**

The timing of each phase of the complex soccer skill was analyzed using the Go-Pro App. Phase 1 started the moment the participant touched the top of the soccer ball with the sole of her foot and ended the moment the right foot stopped touching the ball and the left foot touched the ball (see Figure 1, Photos1-4). Phase 2 was timed from the moment a participant touched the ball with their left foot to the moment the participant touched the ball with their right foot. The timing of the phase could not be calculated if the participant performed the phase unsuccessfully. For each participant, scores were summed across each block and a mean score was calculated in Excel. When the participant performed the phase unsuccessfully, no score was documented and it was subsequently recorded as missing data during the analysis.

### **Absolute Movement Time.**

The absolute timing of each phase of the complex soccer skill was analyzed using the Go-Pro App. The entire skill was timed from the moment a participant touched the ball to the moment she initiated the pass. These scores were averaged for each block and each participant before being analyzed. Absolute timing could not be calculated if the participant performed the skill unsuccessfully. When this occurred, no score was recorded and it was recorded as missing data during the analysis.

## **Analysis**

Statistical analyses for the visual search data were as follows. For each of the dependent variables a separate 2 (Skill: expert/novice) x 2 (Condition: slow-motion/real-time video) x 2 (Blocks: 1<sup>st</sup> and 6<sup>th</sup>) mixed factorial ANOVA's was conducted with repeated measures on the last factor.

Significant main effects were followed by a Bonferroni post hoc analysis using pairwise comparisons to isolate differences for the repeated measures factor, and all interactions were followed up with a simple effects test and Bonferroni's post hoc tests. The experiment wise error rate was set at an alpha level of 0.05. P values, partial eta squared effect sizes and standard deviation scores were reported in this study. Greenhouse Geisser significant levels were used throughout this study.

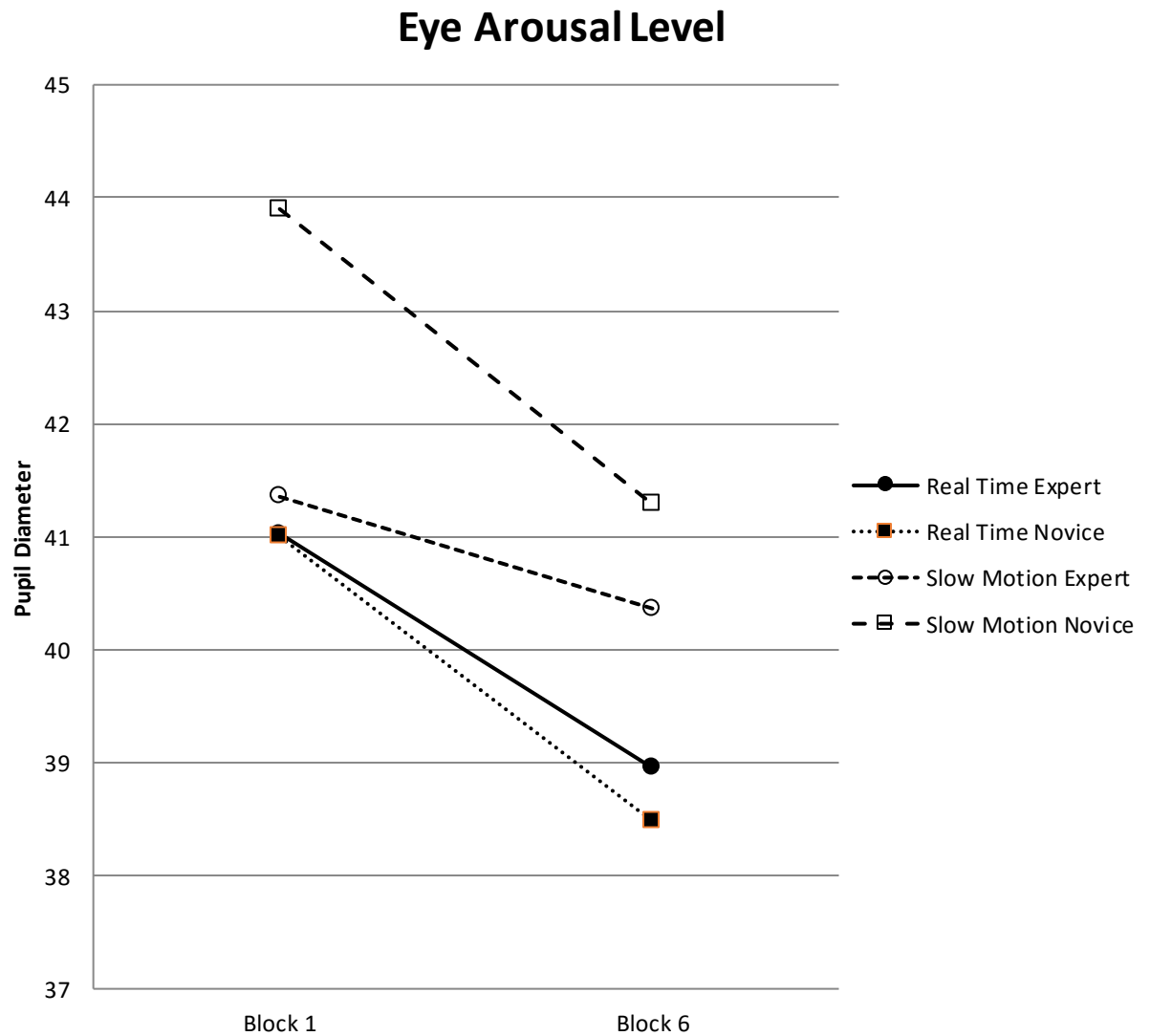
## Chapter 4

### Results

#### Visual Search Data

##### Pupil Diameter.

Analysis of pupil diameter revealed a main effect for blocks,  $F_{(1,28)} = 13.970, P = 0.001$  partial  $\eta^2 = 0.333$ . The pupil diameter in Block 6 ( $m = 39.773$ ,  $SD = 4.772$ ) was smaller than Block 1 ( $m = 41.821$ ,  $SD = 5.416$ ) suggesting that arousal level decreased as a function of practice regardless of video speed demonstration and skill level of participants (see figure 2). Neither the main effect of group or condition were significant nor did any of the factors enter into any 2 way or 3 way interactions ( $F < 1$ ).



**Figure 2.** Mean Scores for Pupil diameter Block 1 and Block 6  
Figure 2. Mean Scores for pupil Diameter block 1 and block 6.

### Gaze Variability.

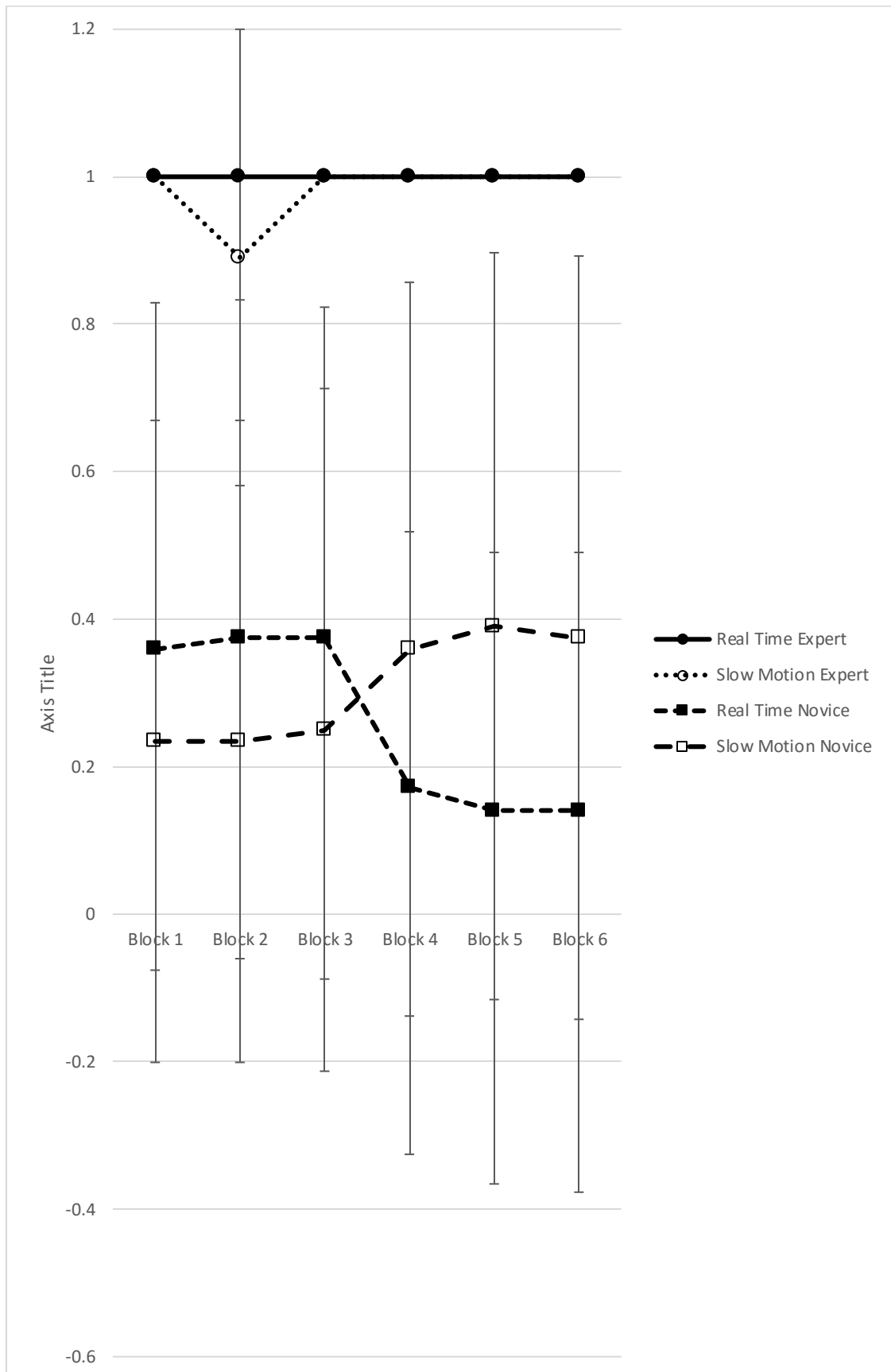
The analysis of gaze variability revealed no main effects for conditions, skill level or blocks nor any 2 way or 3 way interactions. These results suggest that the amount of visual scanning did not differ between video speed or skill level groups, suggesting that despite the novelty of the task, similar eye scanning behavior was adopted by all participants.

## **Movement Outcome**

### **Phase 1.**

Mean accuracy scores revealed a difference between experts and novices.

Whereas experts reproduced this phase immediately, novices experienced greater difficulty with performing this phase despite the fact that this was the easiest phase of the skill (see Figure 3).

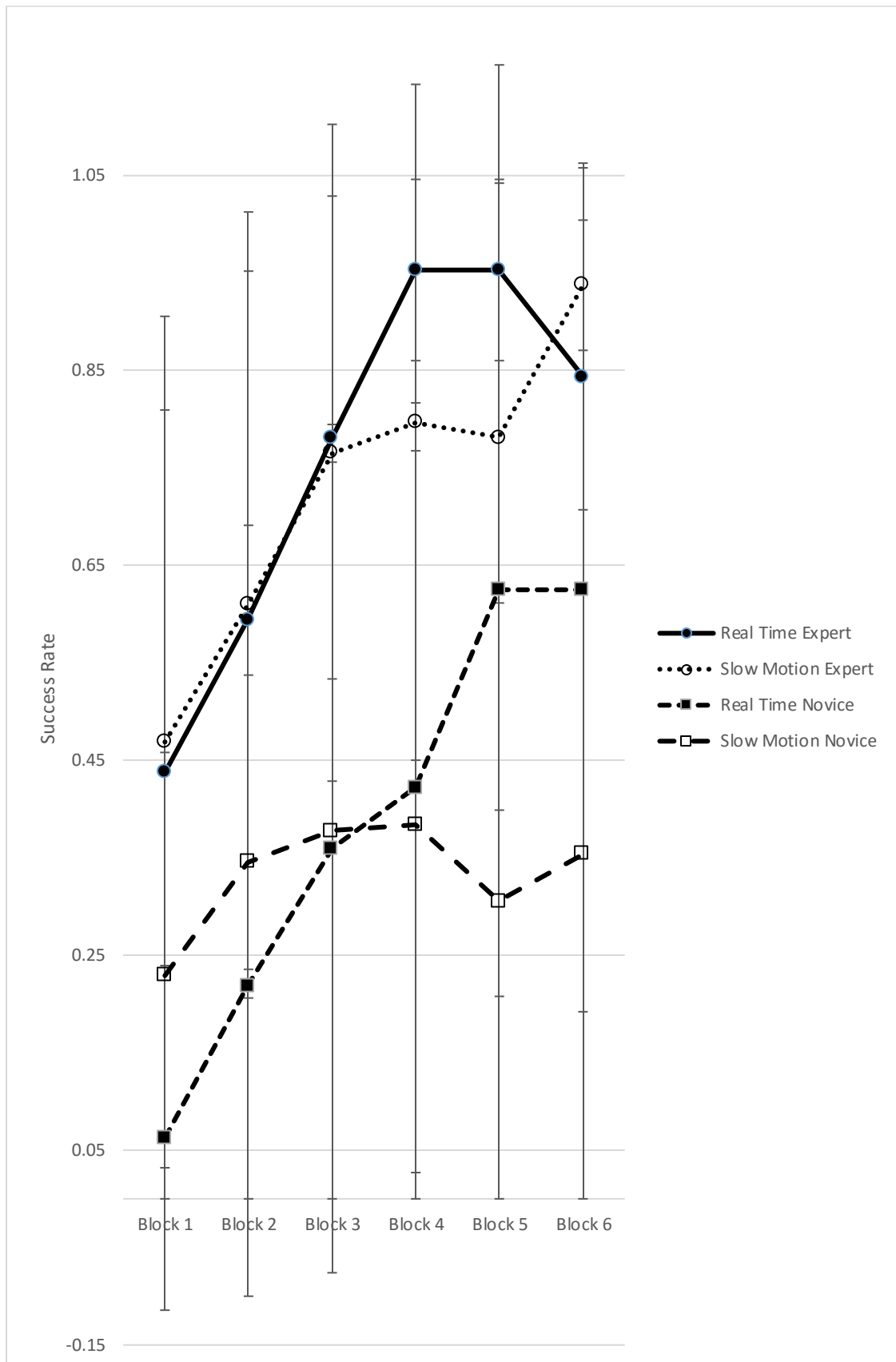


**Figure 3:** Mean number of successful Phase 1 skill reproduction.



## **Phase 2.**

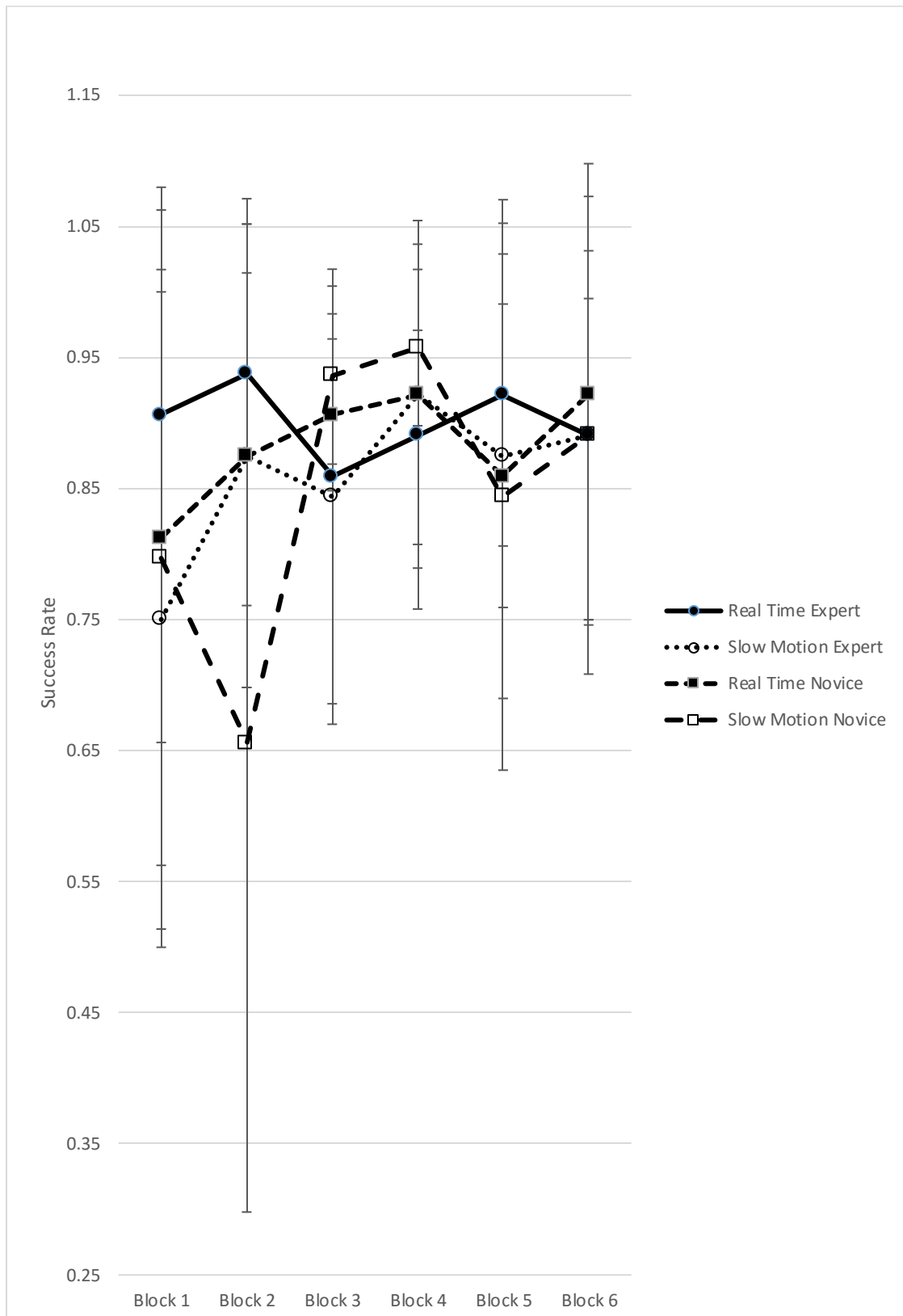
Mean and SD scores can be seen in Table 1. Experts performed better than novices over both conditions, although there was a steady improvement in performance over phase 2 skill reproduction across both groups. Real time experts performed slightly better than slow motion experts in contrast, with the opposite effect demonstrated between real time and slow motion novices (see Figure 4).



**Figure 4:** Mean number of successful motor reproduction of Phase 2 of the complex soccer skill

### **Phase 3: Passing Technique.**

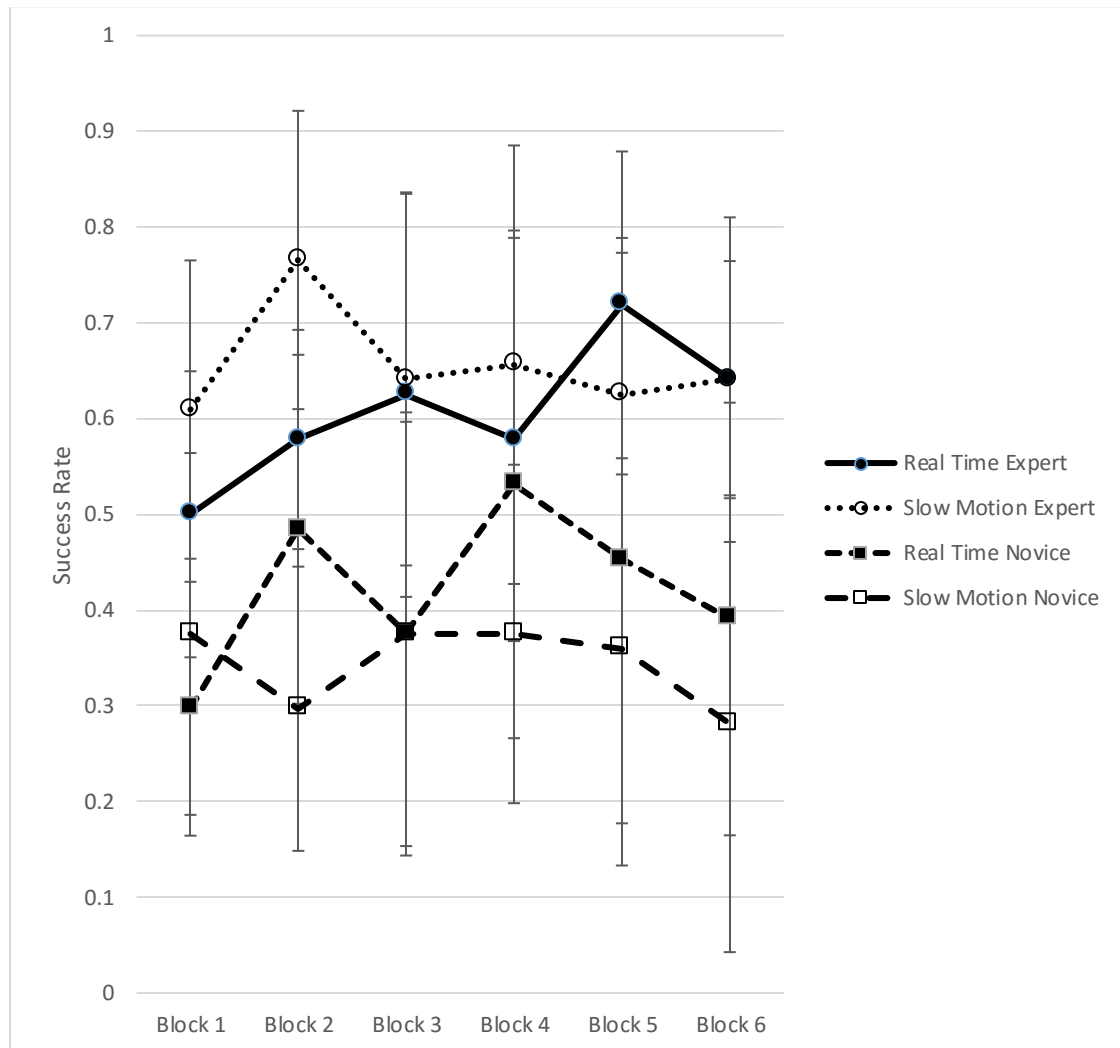
Mean and SD (Table 3) scores showed that there was a steady improvement in passing form and accuracy among all groups. Slow motion novices initially got worse at performing the correct passing technique before getting better. By the end of the practice session, there were very few differences between the experts and novices across viewing conditions (see Figure 5).



**Figure 5:** Mean number of successful Phase 3 skill reproduction.

### Target Accuracy.

Mean and SD results (Appendix A, Table 4) revealed that the expert slow motion and real time group overall hit the target more often than the novices in both conditions (see figure 6). Real time novices and experts showed a larger improvement than the slow motion experts and novices.

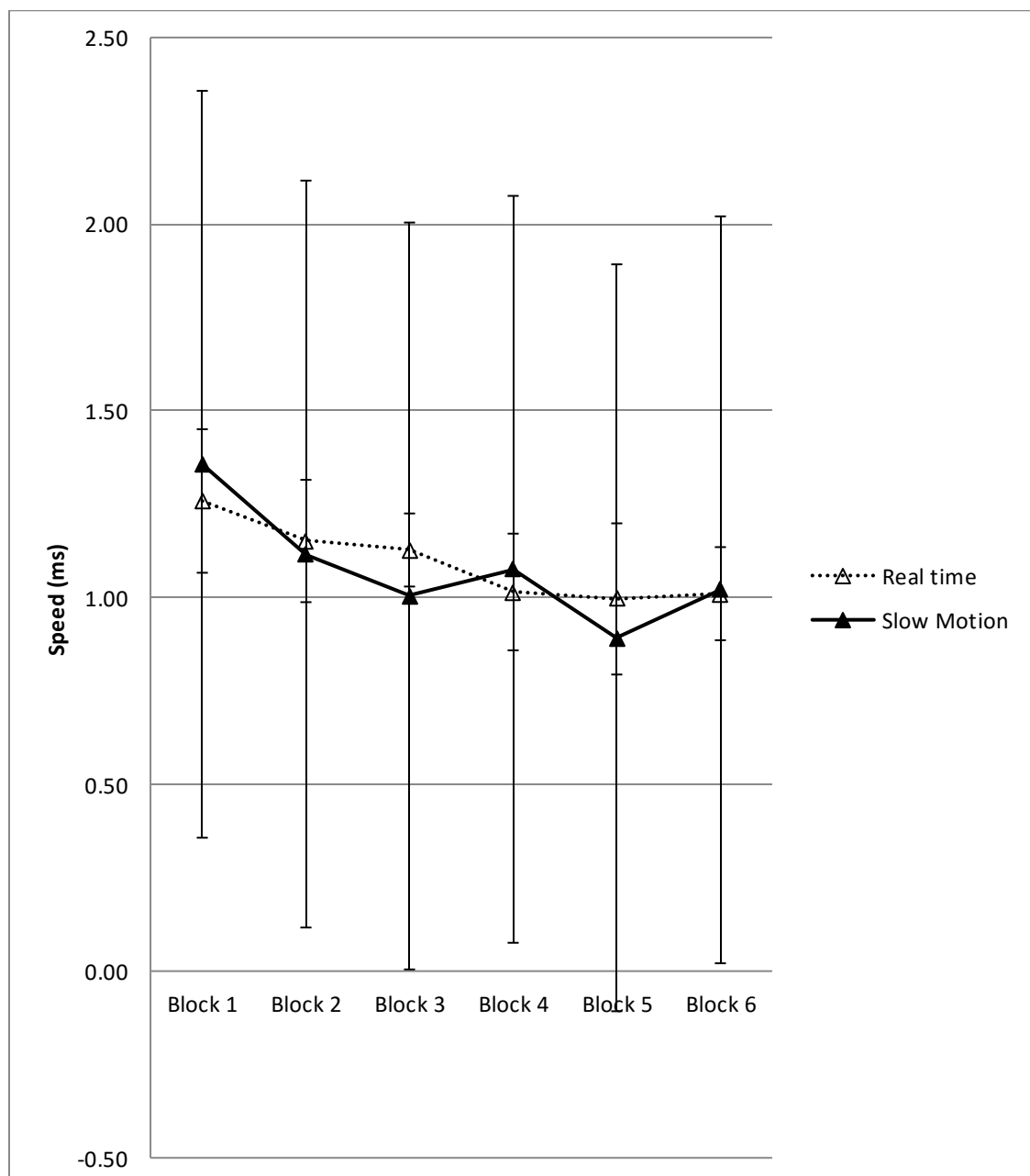


**Figure 6:** Mean number of successful target hits by passing the ball

### Phase 1 Speed.

Due to the extremely low success rate of the novices performing the first phase successfully, only the expert performance was analyzed. The analysis on the means of the relative timing of the first phase of the complex soccer skill revealed a

main effect for blocks,  $F_{(5,40)} = 7.718$ ,  $P < 0.001$  partial  $\eta^2 = 0.491$  but no group main effect or significant interactions. Post hoc analysis of the main effect of blocks revealed that both groups got progressively quicker at performing the first part of this complex skill from their first block to their final block. Figure 7 shows similar performance levels between groups regardless of the video speed manipulation.



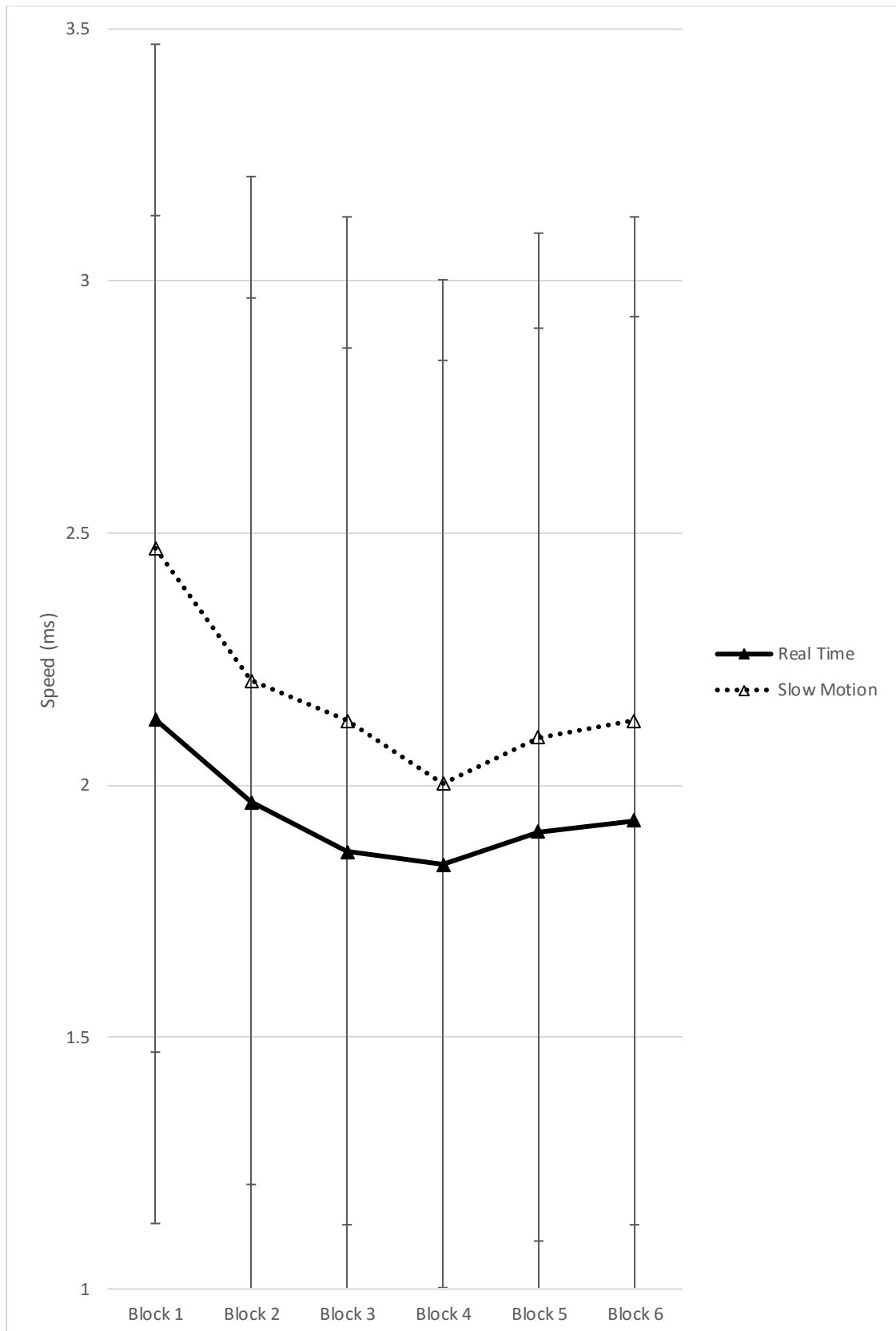
**Figure 7:** Mean scores for relative timing phase 1: Experts

### **Phase 2 Speed.**

No significant main effects were observed for the relative timing of the second phase of the complex soccer skill, suggesting performance for this phase remained the same despite practice and the video speed manipulation.

### **Absolute Timing.**

Analysis of the absolute timing of the overall complex soccer skill (phase 1 -3 together) showed a block main effect,  $F_{(5,40)} = 12.447$ ,  $P < 0.001$  partial  $\eta^2 = 0.609$ . These results indicate that observation of an expert model under real time or slow motion conditions led to comparable improvements in performance of the overall task (see Figure 8). Both groups performed fastest in block 4, as confirmed through post hoc analysis.



**Figure 8:** Mean scores for Absolute timing of Complex motor skill: Experts



## **Chapter 5**

### **Discussion**

The purpose of this research was to identify performance differences between experts and novices as a function of slow motion and real time video presentation of a skilled model and to identify visual search strategy differences between experts and novices viewing a model at slow motion and real time video speed.

The expert skill level group's pupil diameter (arousal) was expected to be less than the novice skill level group's under both the real time and slow motion conditions. Experts, who have a vast repository of game experience, are capable of processing information with less effort than novices (Kahneman, 1973, Laukkonen, 2012). Slow motion novice's tended to show more arousal initially, but decreased as a function of practice. Hence, as expected the slow motion group was the most aroused while observing a skilled model perform the complex soccer skill. This result is consistent with Beatty's (1982) work on pupil dilation during cognitively demanding work. When performing a cognitively demanding task, pupils dilate in response to the psychological workload of the task and constrict after the task is finished. This suggests that processing load is "construed as analogous to an aggregate demand for power" (Beatty, 1982 p291). In other words, pupillary response is dependent on the processing load of a task (Kahneman, 1973, 2012; Beatty, 1982). The greater the processing load, presumably as a result of the novelty of the task, the greater the pupillary response and vice versa. Participants, having seen a complex skill both cognitively and physically, showed dilated pupils, however, their pupils constricted as they became familiar with the complex motor skill. Constriction of the pupils indicates a loss in arousal and subsequent attention (Hess and Polt, 1960). This concept also supports the novice and experts' assignments.

It was anticipated that experts observing the slow motion video model would view more relevant cues than the novices, however the slow motion novice group would show similar viewing patterns to the expert skill level group. The results from this study showed that visual search data between experts and novices did not differ, indicating that similar viewing strategies were employed by both experts and novices regardless of viewing speed.

Slow motion video speed was expected to produce greater successful reproduction of each Phase of the complex motor skill (i.e. roll over, step over and pass). Experts were expected to perform better than the novices regardless of the video speed observed. Phase 1 success rate showed how the experienced or skilled soccer players (experts) who observed the real time and slow motion video model, overall performed the roll phase of the soccer skill better than their novice counterparts. The experts were able to complete the first phase in both the real time and slow motion observational learning groups almost immediately. The novices on the other hand struggled to complete the first phase of the skill. The experts regardless of video speed condition performed significantly better at Phase 1 of the complex skill than the novices in both video speed conditions over the six practice blocks. Although this was a relatively simple component of the skill for the experts, visual inspection of the practice videos, revealed that the novices failed to notice that the expert model used the sole of her foot to perform the skill, and instead used the inside portion of their foot to perform the roll portion of the soccer skill. It may be that experts have experience using the sole of their feet while novices do not. Hence, experts are able to pick up this perceptual information since they actually perform skills using this part of their feet. Since novices have never used the bottom of their feet, they do not perceive its use. This action may have contributed to their poor performance during

Phase 2, where control of the ball position would greatly assist in initiating the next phase.

Phase 2 exhibited the most interesting results. This phase was the most difficult phase of the overall skill as it contained the very complex step over sequence. The experienced soccer players performed the second phase of the complex soccer skill successfully more often regardless of the video condition compared to the novice soccer players. The experts, however, really struggled with the acquisition of this portion of the skill, which was not expected. Despite experts struggling with this phase, their success during Phase 1 allowed for greater control during initiation of Phase 2, which in turn lead to improved performance during this phase. Performance on the second phase of the soccer skill improved across all blocks of the practice phase. In other words, experts differed to novices and both groups improved over the course of the 6 blocks. The real time observational learning group performed slightly better than the slow motion group although no significant main effect was observed. This is congruent with Kalyuga et al.'s (2012) investigation into the expertise reversal effect in cognitive load theory. Although this has mostly been investigated in the area of complex cognitive skills it has been extended to complex motor skills. Kalyuga et al. (2012) explains that novice performance may be enhanced by instructions to explicitly focus attention on step-by-step performance (in this study slow motion video broke the skill down into three distinct phases). This type of attention seems to have been counterproductive for experts. Experts benefitted from the real time video model, which focused purely on skill execution and prevented interruptions to their automated processes, presumably because the absolute timing of the task was preserved. Although improvements were seen as a function of practice, it is likely that additional practice is required to impact performance for both experts and novices.

Phase 3 analysis revealed a learning effect of the correct passing technique across practice. The success rate of Phase 3 then plateaued whereby all groups had minimal differences in success rate. For experts a pass is a skill, which is used consistently in drills, training and games and thus did not impose a significant challenge to these experts. It is also a simple skill that can be taught rapidly to novices.

The complex soccer skill was designed so that it posed a challenge for both skill level groups, which in turn would make it possible to identify changes in eye gazing behavior and performance outcome as a function of practice. However, the position of the expert soccer player on the soccer field (Striker, Midfielder, Defender, and Goalkeeper) could play a role in whether or not the expert players could successfully reproduce the complex skill. The fact that the real time experts performed better than the slow motion experts suggested that the slow motion video observational learning tool might have hindered the learning of this complex skill. This is in line with the work of Barclay, Cutting and Kozłowski (1978) which stated that observation of slow motion presentations may hinder the recognition of actions. , and clearly, for experts who were familiar with many soccer skill techniques, the novelty of the one used in this study proved more challenging when presented under slow motion conditions. In contrast, the slow motion observational learning tool allowed for better reproduction of the complex skill for novices who viewed the model in slow motion although the results must be interpreted with caution due to the inability to perform statistical analysis. Although improvements were seen across practice, it is likely that additional practice is required to impact performance for both experts and novices. According to Newell's (1985) philosophy on coordination, control and skill, both experts and novices were working on assembling the novel

movement topology (coordination). Towards the later stages of the practice session experts would be expected to begin to parameterize the movement pattern. Novices never reached this stage, and in fact, skilled reproduction was not reached during this study. More practice would be needed in order to extend the continued scaling of the movement pattern in order to reach the successful “skill” reproduction stage. Target scores showed that experts performed significantly better than the novices at hitting the target. This was anticipated as the experts passing technique should be considerably more accurate than a novice who has no experience of playing soccer. There were no significant effects for video speed condition, or any significant interactions. Although the video speed condition did not reveal any significant results the real time novices hit the target more often than the slow motion novices and there were minimal differences between real time experts and slow motion experts. This finding is consistent with the theory that observational learning is dependent upon the task outcome and the learner’s goals (Hodges et al., 2005, 2007). The real time group for both experts and novices failed to secure the second phase of the complex soccer skill, but attended to the parts of the skill which were more in their control like Phase 3 (passing the ball accurately and correct form) and hitting the target.

Due to the extremely low success rate of the overall skill, only the experts’ Phase 1 and 2 video speed and absolute timing of the complex soccer skill were analyzed. Speed of Phase 1 got faster as a function of practice. Absolute timing of the overall skill showed a Block effect in that both conditions improved (became faster) over the six Blocks. As expected the real time observational learning group performed faster over all blocks than the slow motion observational learning group. This is consistent with findings that slow motion demonstrations could in fact hinder the acquisition of absolute motion information (Al Abood et al., 2001b, Williams, 1989b)

for experts. On top of this, it has been shown that relative motion is not essential for the acquisition of coordination (Hodges et al., 2005) and that participants sometime focus their attention on absolute features of the movement to aid in successful skill reproduction. Observers have shown themselves to be somewhat selective in terms of the amount and type of information attended to when trying to imitate a movement.

The slow motion video observational learning tool aided both skill level groups acquire either the phases or overall skill in general terms. Real time however, helped the experts acquire the skill quicker and better than the slow motion video observational learning tool. This result is consistent with the work of Al Abood et al. (2001) who found that a slow motion video speed model was detrimental to a models spatial and temporal relative motions as well as performance scores. On the other end of the spectrum, Put, Wagemans, Pizzera and Williams (2016) investigated the offside decision-making performance of international level assistant referees. Results revealed that scheduling a decreasing video speed sequence during training is more beneficial to enhance skill learning than real time or increasing speed conditions. In other words, this study offers evidence to suggest that elite performers may benefit from slow motion video training during the learning process may be more beneficial than regular speed video presentations. It is also important to note that upon completion of the practice session, two of the experts mentioned that they were particularly nervous performing the skill in front of a camera and in the lab. The anxiety associated with this may in fact have confounded the pupil size during the visual search data collection and may have had an impact on participants' subsequent performance. If expert soccer players experienced anxiety it would be accurate to assume that novices also had high levels of anxiety. This in turn may also have influenced their results.

### **Limitations and Future Directions**

A major limitation of this study was the fact that it was extremely difficult to pinpoint exactly where participants were looking in the video. Because the video model was viewed moving toward the observer's point of view and across the screen, it was very difficult to distinguish whether the participant was looking at the foot, knee, hip, ball, head, etc. over the duration of a trial. This limitation made it impossible to determine whether experts attended to more relevant cues compared to novices during observation trials, and whether novices who observed a slow or real time motion model adopted different visual gazing strategies that might have led to performance differences.

Another limitation of this study was the sample size and selection. It would be beneficial to perform a similar study using a larger and more homogenous sample which would allow real differences to emerge. The fact that the majority of the participants were recruited from the Kinesiology program meant that they may have had previous athletic experience which may not be a good representation of the general population. The skill itself may have been too challenging and that more practice would be necessary to allow differentiation between video speeds.

The implication of "age" on the coordination of the task is also another limitation, which ties into the skill itself. Older individuals, especially those who have engaged in various sports, have a repertoire of movement skills they have developed that could be adapted to perform a novel motor task. The sample recruited for this study used adult females who may already have the relevant coordination to perform various parts of this complex skill, and these athletes may focus on different cues conveyed by a model than a younger, less experienced athlete may focus on because they have not yet developed the appropriate coordination. The skilled model and the

information conveyed by the model has to be age specific to cater to the capabilities of the observer (age and ability).

The skill in itself includes a variety of temporal and spatial parameters. It could be argued that perhaps the skill itself was broken down into too many parts, and that parsing the skill as such would disrupt the relative timing of the various components. The skill may also have been better viewed from behind rather than from the front to avoid participants having to translate the visual representation into its reverse motor action. Additionally, an additional practice session to allow for information to be consolidated may have uncovered performance differences that a single session did not permit. It would also be interesting to measure heart rate using a polar watch to monitor anxiety levels. There are also multiple questionnaires which can measure anxiety levels such as the Physical Activity and Sport Anxiety Scale (Norton, Hope & Weeks, 2004). This may explain if there was confounded pupil size or poor performance based on anxiety.

The design of this study did not lend itself well to a comparison of differences that would allow the investigator to identify which group performed significantly better. Future studies using this particular design should use a continuous scoring system. The performance score would be based on different criteria which would give a range of scores which would allow for a parametric difference test.

Additional research is needed to establish what experts are focusing their attention on while watching a complex skill being performed in comparison to their novice equivalent. Future research needs to distinguish more homogenous groups, in that it would be interesting to repeat the study using professional soccer players/academy soccer players. In order to ensure that this happens, it is imperative



that the skilled group should be pre-tested to assess their expert level and soccer playing ability level.

## **Conclusion**

To our knowledge, this is the first study of its kind. Future research focusing on the acquisition of motor skills through observational learning should compare areas of interest and pupil diameter to ascertain their effectiveness for learning in a variety of sports across genders. Moreover, research is needed to establish what experts focus their attention on while observing a skilled model. It may be beneficial to monitor what experts and novices look at by highlighting the key features for the learning of complex skills. In turn it is important to know whether or not slow motion or real time video speed observational learning tools can impact skill acquisition in soccer but also in a variety of other sports.

Sports coaches, instructors and teachers need to be aware of whether slow motion video speed is beneficial at the beginning of skill learning or to help expert's fine tune a complex skill. Because of the widespread availability of smartphones, tablets, etc. this information can be extremely influential in the maximization of skill learning in youth athletes. The simplicity and brevity of this intervention suggests that it may be implemented effectively in a wide variety of contexts, both in the sporting world and otherwise.

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Appendix A Means Tables

Table 1  
Success Rate Phase 1

Expert													
	Block 1 M	Block 2		Block 3		Block 4		Block 5		Block 6			
		SD	M	SD	M	SD	M	SD	M	SD	M		
Real Time	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	0.000
Slow Motion	1.000	0	0.891	0.309	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	0.000
Novice Phase 1													
	Block 1 M	Block 2		Block 3		Block 4		Block 5		Block 6			
		SD	M	SD	M	SD	M	SD	M	SD	M		
Real Time	.359	.469	.375	.458	.375	.448	.172	.347	.141	.349	.140	.349	.349
Slow Motion	.234	.435	.234	.435	.25	.463	.359	.497	.391	.467	.375	.517	.517

Table 2  
Success Rate Phase 2

Experts												
	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Real Time	.437	.372	.593	.358	.781	.247	.953	.093	.953	.093	.843	.219
Slow Motion	.468	.436	.609	.403	.765	.336	.796	.346	.781	.382	.937	.066
Novices												
	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Real Time	.062	.176	.218	.318	.359	.435	.421	.394	.625	.417	.625	.433
Slow Motion	.156	.229	.218	.345	.5	.377	.437	.383	.671	.305	.625	.353

Table 3  
Success Rate Phase 3

	Experts											
	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Real Time	.906	.11	.937	.133	.859	.123	.890	.080	.921	.148	.890	.104
Slow Motion	.75	.25	.875	.176	.843	.173	.921	.132	.875	.115	.890	.140
Novices												
	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Real Time	.812	.25	.875	.176	.906	.057	.921	.114	.859	.169	.921	.062
Slow Motion	.796	.282	.656	.358	.936	.067	.957	.059	.843	.208	.890	.182

Table 4  
Success Rate Target Accuracy

Experts													
	Block 1 M	Block 2		Block 3		Block 4		Block 5		Block 6			
		SD	M	SD	M	SD	M	SD	M	SD	M		
Real Time	.5	.149	.578	.114	.625	.211	.578	.210	.718	.160	.640	.123	
Slow Motion	.609	.155	.765	.155	.640	.194	.656	.229	.625	.163	.640	.169	
Novices													
	Block 1 M	Block 2		Block 3		Block 4		Block 5		Block 6			
		SD	M	SD	M	SD	M	SD	M	SD	M		
Real Time	.296	.132	.484	.182	.375	.221	.531	.265	.453	.319	.390	.225	
Slow Motion	.375	.188	.296	.148	.375	.231	.375	.176	.359	.182	.281	.238	

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